

# Distribution and Interconnection R&D: Strategic Roadmap Planning

## *Annual Program Review*

January 22, 2003

Washington, D.C.



Presented by N. Richard Friedman  
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# Objective of Today's Meeting

- Explore options for Distribution & Interconnection System R&D
- Envision what the interconnection system of the future might look like
- Discuss the “seamless” integration of DER with the grid
- Examine “optimal” R&D role for DOE

# What We Are Not Going to Do

- Identify where the work will be done
- Pin down R&D content to a specific program area
- Identify who will fill stakeholder and contractor roles

# What Will Be Done As R&D Activities Evolve

- Retain DOE flexibility
- Keep R&D options open
- Seek to refine and implement new activities over the next decade as the electric distribution system evolves into a smart, reliable and DER supportive grid
- Fund selected efforts conducted by industry, universities, and others that move to fulfill the steps agreed upon in the Strategic Roadmap

# Creating the Foundation of a Strategic Roadmap

- Focus on Distribution & Interconnection R&D
  - Market and technology research
  - Stakeholder interviews
  - Series of meetings and workshops
- Purpose of discussion draft
  - Spur discussion
  - Invite constructive stakeholder critique
  - Establish common vision of future
- Next steps
  - Input from this meeting
  - Follow-up meetings and discussions

2020  
2010  
2003

# The Systems Aspects of Distributed Power - The Federal Government Interest

- Impact on electric industry competition
- Concern over reliability and security of our electric power supply
- Lower barriers that limit use of improved distributed generation and storage devices
- Leverage government investment





# Industry Input

ABB Automation, Inc.	Cutler-Hammer	Heart Interface
Advanced Energy Inc.	Cyberex	Heliotronics, Inc.
AeroVironment Inc.	Delphi Automobile Systems	Hess Microgen LLC
Alpha Power Systems, Inc	Detroit Edison	Honeywell Power Systems
American Public Power Association	DTE Energy Technologies	Hydrogenics Corporation
Ametek Power Instruments	Ecostar Electric Drives	Ingersoll-Rand Energy Systems
ASCO Power Technologies	Elliott Energy Systems, Inc.	Integrated Power Solutions
AstroPower, Inc.	Encorp, Inc.	Intellicon
Baldor Electric Company	Enercon Engineering	Invensys PLC
Ballard Engineering	Enetics, Inc.	Inverpower Controls Ltd.
Basler Electric Co.	EPRI PEAC Corp.	Kohler Corporation
Beckwith Electric Co., Inc.	GE Power Systems	L-3 Communications
Capstone Turbine Corporation	GE Zenith Controls, Inc.	SPD Technologies
Caterpillar Inc.	Generac Power Systems	Magnetek Power Electronics Group
Celerity Energy	GE Corporate R&D	Measurelogic Inc.
ConEdison	Genergy	
Cummins Power Generation	H Power Corporation	



# Industry Input (continued)

Mitsubishi Heavy Industries America  
National Institute of Standards &  
Technology  
Northern Power Systems  
Nova Electric  
NRECA Cooperative Research  
Network  
Oak Ridge National Laboratory  
Omnimetrix  
Petrotech  
Plug Power, Inc.  
Power Distribution, Inc.  
Power Measurement  
Puget Sound Energy  
Reliable Power Meters  
S&C Electric Co.  
Satcon Technology Corp.

Schweitzer Engineering Labs  
Shallbetter Inc.  
Siemens Westinghouse Power  
Corporation  
Silicon Energy  
Simpson Electric  
SMA America  
Solar Turbines Incorporated  
Solectria Corporation  
Solidstate Controls  
Sonat Power Systems, Inc.  
Square D Co / Schneider Electric  
Tecogen, Inc.  
The University of Tennessee  
Thermo Westronics  
Thomson Technology

Toshiba International  
Corporation  
Trace Technologies Corporation  
University of Minnesota  
Univ. of Wisconsin-Madison  
UTC Fuel Cells  
Vanner Incorporated  
Visteon Distributed Power  
Generation  
Waukesha Engine Division  
Woodward Industrial Controls  
Xantrex Technology Inc.



# Distribution & Interconnection R&D

- - - supports the development of a modernized, reliable, highly automated and more efficient electric power distribution system with fully-integrated distributed energy resources.

(generation, storage, demand response)

# Strategic Goals



- Build a foundation for reinventing the electric power distribution system
- Enjoy the benefits of improved interconnection and distribution systems
- Construct a bridge to the future
- Leverage on the SMARTConnect™ concept and DER integration

# Build a Foundation for Reinventing the Electric Power Distribution System

- R&D on interconnection and distribution system integration technologies
- Mitigation of barriers
- Federal leadership role in supporting creation of a viable market for distributed power - “unite” stakeholders
- Push technologies that will help create a “modernized” electric power distribution system

# Enjoy the Benefits of Improved Interconnection and Distribution Systems

- A modernized electric power distribution system
- Standardized interconnection requirements
- Availability of affordable and reliable modular interfaces
- Creation of a regulatory and institutional environment that recognizes the benefits of DER and supports its use

# Construct a Bridge to the Future

- Support National Energy Policy Goals
- Input from FERC
- Support DOE strategic goals
- Support National Transmission Grid Study recommendations



# Leverage on the SMARTConnect™ Concept & DER Integration

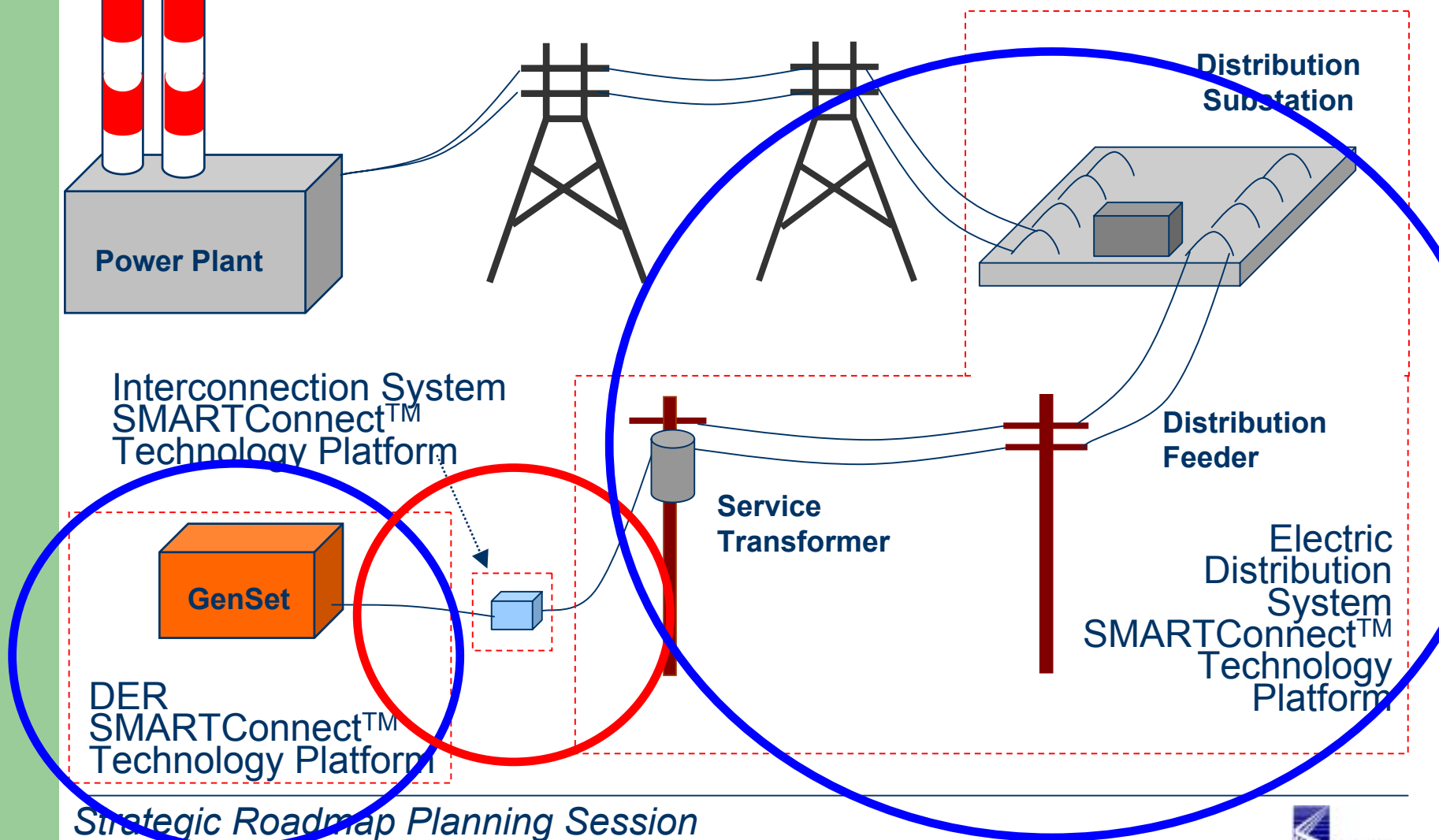
*SMARTConnect™ consists of a set of technology platforms that support the development of a modernized, reliable, highly automated and more efficient electric power distribution system with fully-integrated distributed energy resources.*

## SMARTConnect™ Technology Platforms:

- DER technology communications and controls
- Interconnection system technologies
- Electrical distribution system technologies

# SMARTConnect™ Technology Platforms

*A natural evolution of technology development*

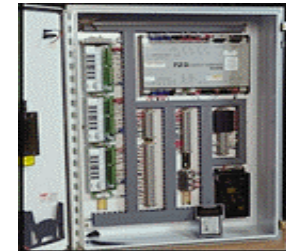


Strategic Roadmap Planning Session

January 22, 2003

# SMARTConnect™ Technology Examples

- Equipment
  - Digital relays, controls & other devices
  - RTUs with improved monitoring & reporting
- Capabilities
  - 2-way communication
  - 2-way electrical flow
  - Electric equipment diagnosis
  - Real-time video capturing and transmission
  - Signature analysis
  - Security supervision





# Electric Distribution System of the Future



- System will allow:
  - Actions to be taken quickly
  - Aggregating and balancing of generation and load
  - Maintaining voltage & frequency within central control authority specified limits
  - Dispatching reliability services in response central control authority commands
- System will have the following key capabilities:
  - A layered control system that satisfies the needs of the customers, the local distribution system and the transmission grid
  - A protection system that accommodates routine two-way power flow with localized generation/storage
  - Ability to rapidly change configuration, island, re-align, start and stop generation

# A Future Distribution System Today

- Solution implemented by foreign utility
- New system capable of automatically detecting and isolating a fault on a feeder
- Key - restore power to the feeder within 20 seconds of the fault
- Isolation of faulted section
- Connection of faulted feeder with adjacent feeder
- Automated supervisory restores power to the feeder

# Impacts of DER Integration Through SMARTConnect™



- Portfolio of technologies located in DER package, interconnection system or on the grid
- Allows DER to strengthen and support the central-station model of generation, transmission and distribution
- One vision of the future – “Certified SMARTConnect™ Compatible”
- Lower barriers to DER integration

# Barriers to DER Integration



- 40 to 60-year old grid design technology
- Limited distribution system monitoring and automation capability
- Limited experience with customer generation
- Regulatory and institutional barriers



# Recent R&D Efforts – Manufacturers

- Integration of interconnection equipment with genset
- Use of more reliable, lower cost components
- Convergence of hardware and software
- Improved protective relay performance
- Networking of communications and controls
- Improved trend analysis
- Controls for real-time monitoring and operation

# Recent R&D Efforts – Associations

- EPRI/E2I
  - DER program
  - CEIDS
  - Distribution program
- GTI
  - Integrated Switchgear and Interconnection System
  - Cooperation with UL



# Examples of Recent DOE R&D Efforts



- Interconnection standards development
  - Testing (IEEE P1547.1)
  - Application of IEEE 1547 (IEEE P1547.2)
  - Communications (IEEE P1547.3)
- Interconnection and control technology
- Interconnection and distribution system testing
- Distribution system and grid support applications

# Priority R&D Needs



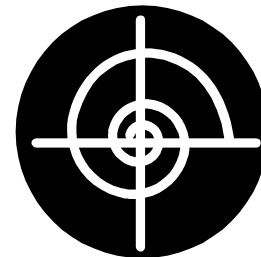
- New protection schemes (e.g., fault detection, anti-islanding, controlled islanding) for two-way power flow
- System control models that incorporate automatic local contingency response
- Interfaces that control power flow, voltage and frequency
- Advances in low-cost communication and control networks and advanced SCADA that enable aggregations of DER to be an integrated operation with scalability
- Digital programmable relays, improved sensors and controls, and expert systems that enable real-time DER dispatch and monitoring
- Real-time monitoring equipment for incipient fault detection and self-repair



# Priority R&D Needs (continued)



- Standards that clearly state the requirements for interconnection of DER equipment
- Modular, standardized interconnection devices that allow DER to be readily and inexpensively interconnected
- Modifications to the electrical distribution system that increase its reliability, lower maintenance costs, and ensure secure operations
- Low-cost converter technologies that enable direct current distribution networks
- Improved distribution system VAR support without necessarily adding new generating capacity
- Smart substation designs that allow real-time control of DER microgrids

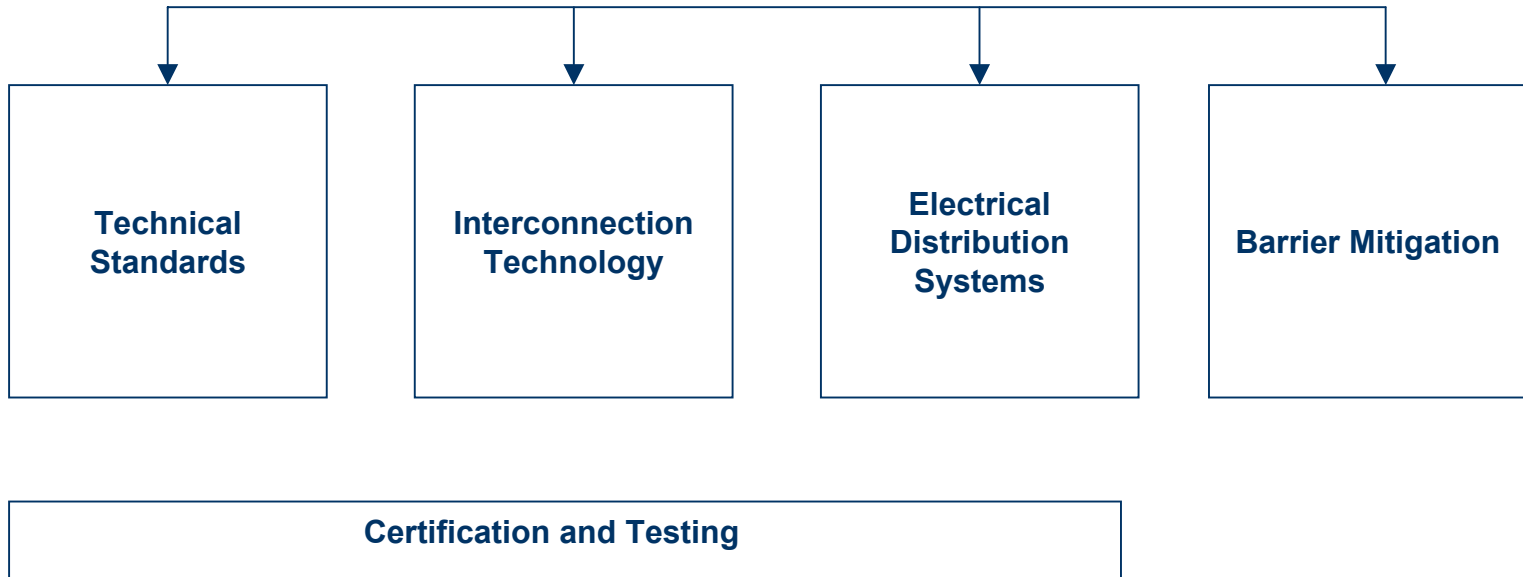


# D&I Targets and Timelines

1. By 2010, develop and publish a body of technical standards facilitating the commercialization of mass-produced, certified interconnection equipment – simplifying the interconnection process.
2. By 2010, as one platform of SMARTConnect™ technology, develop a modular interconnection device that allows plug-and-play interconnection of DER equipment.
3. By 2010, identify and remove regulatory and institutional barriers to DER.
4. By 2015, develop next generation distribution technologies that make distribution systems more efficient, adaptable, reliable, secure, and fully integrate DER.



# D&I R&D Activities

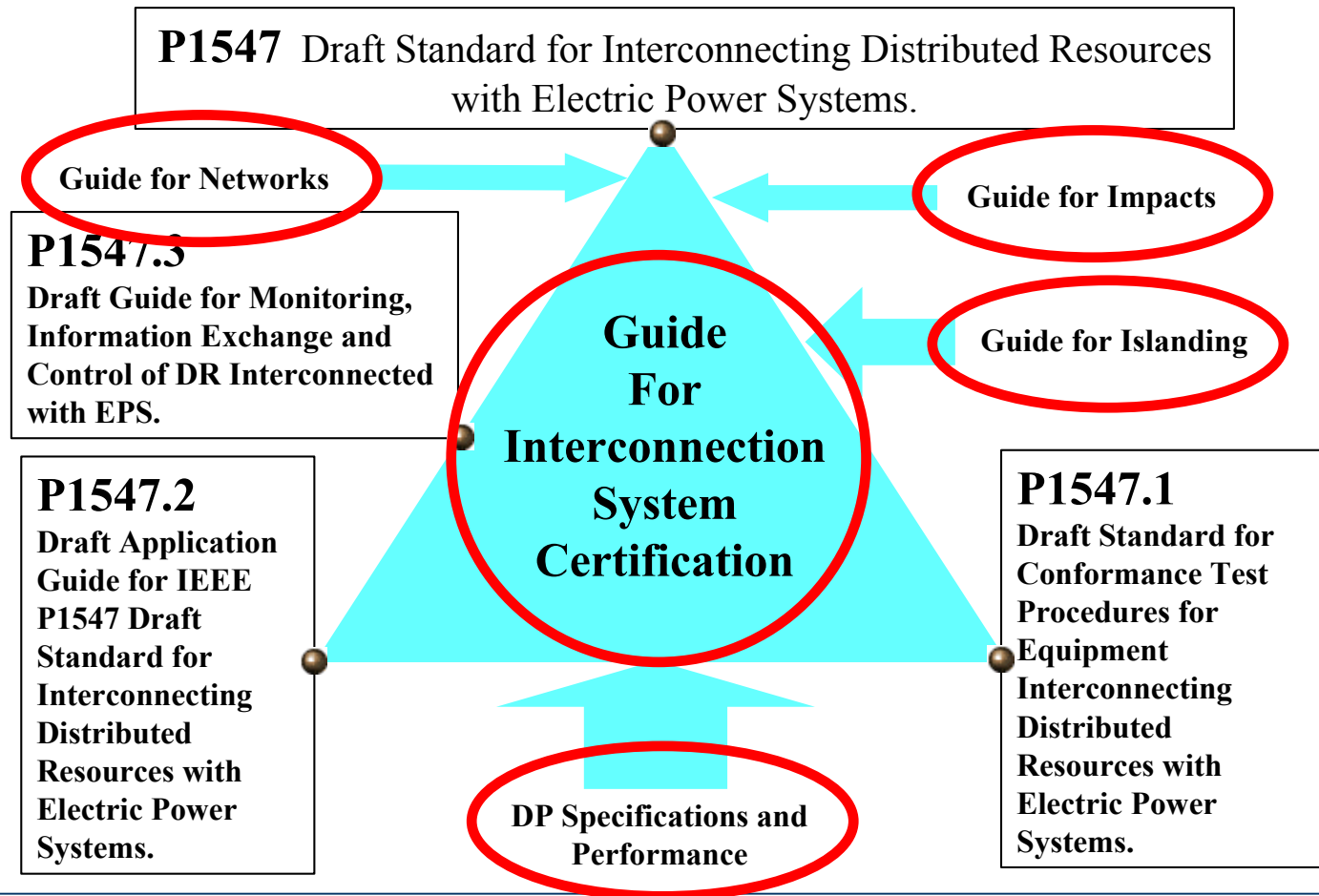


# Technical Standards

- Cross-cuts all areas
- Much work already completed
- Completion of body of 1547 standards

# Technical Standards

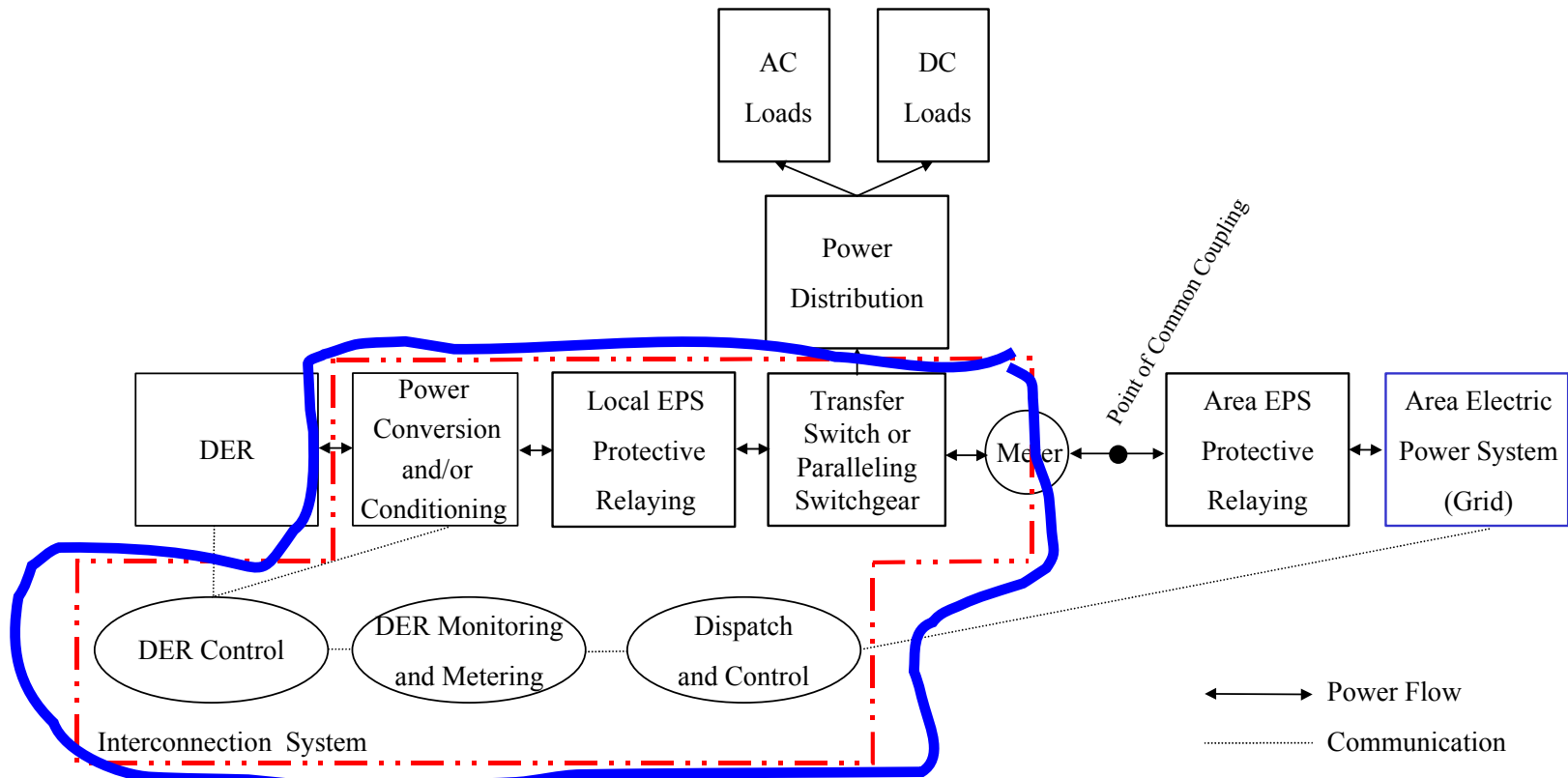
## IEEE SCC21 P1547 Series of Interconnection Standards



# Interconnection Systems

- One technology platform of SMARTConnect™
  - Non-inverter interconnection technology
  - Inverter interconnection technology
- Integration with other SMARTConnect™ technology platforms

# Interconnection Systems

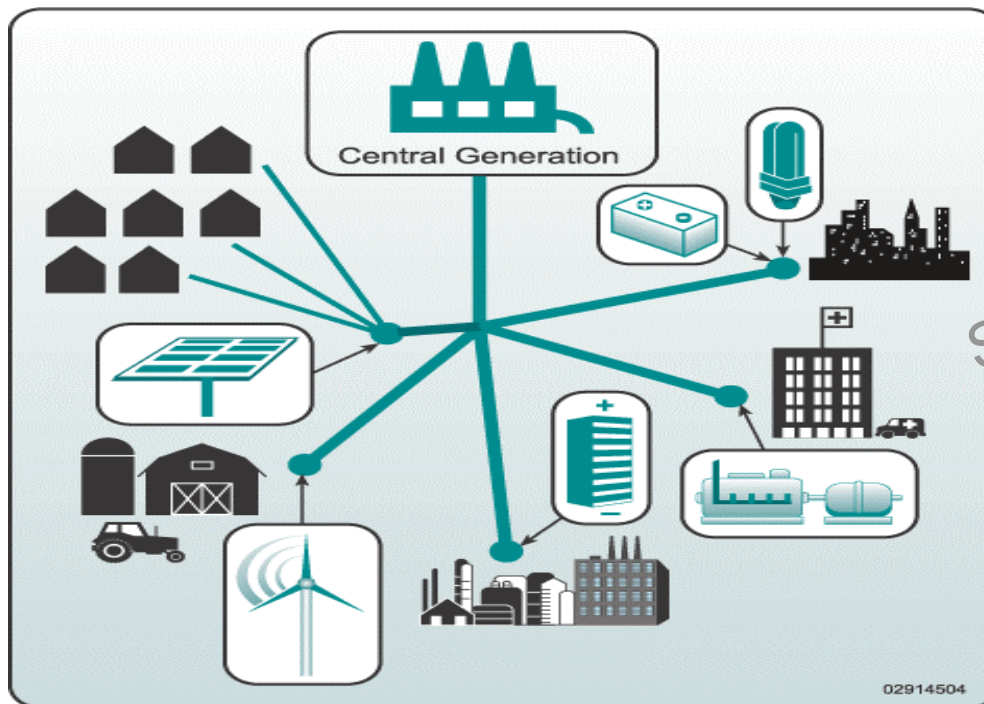


# Electric Distribution Systems

- Needs assessment
- Intentional islanding
- Protection schemes
- Micro grid operation
- Sensors and controls
- Advanced grid control and SCADA
- Smart substations



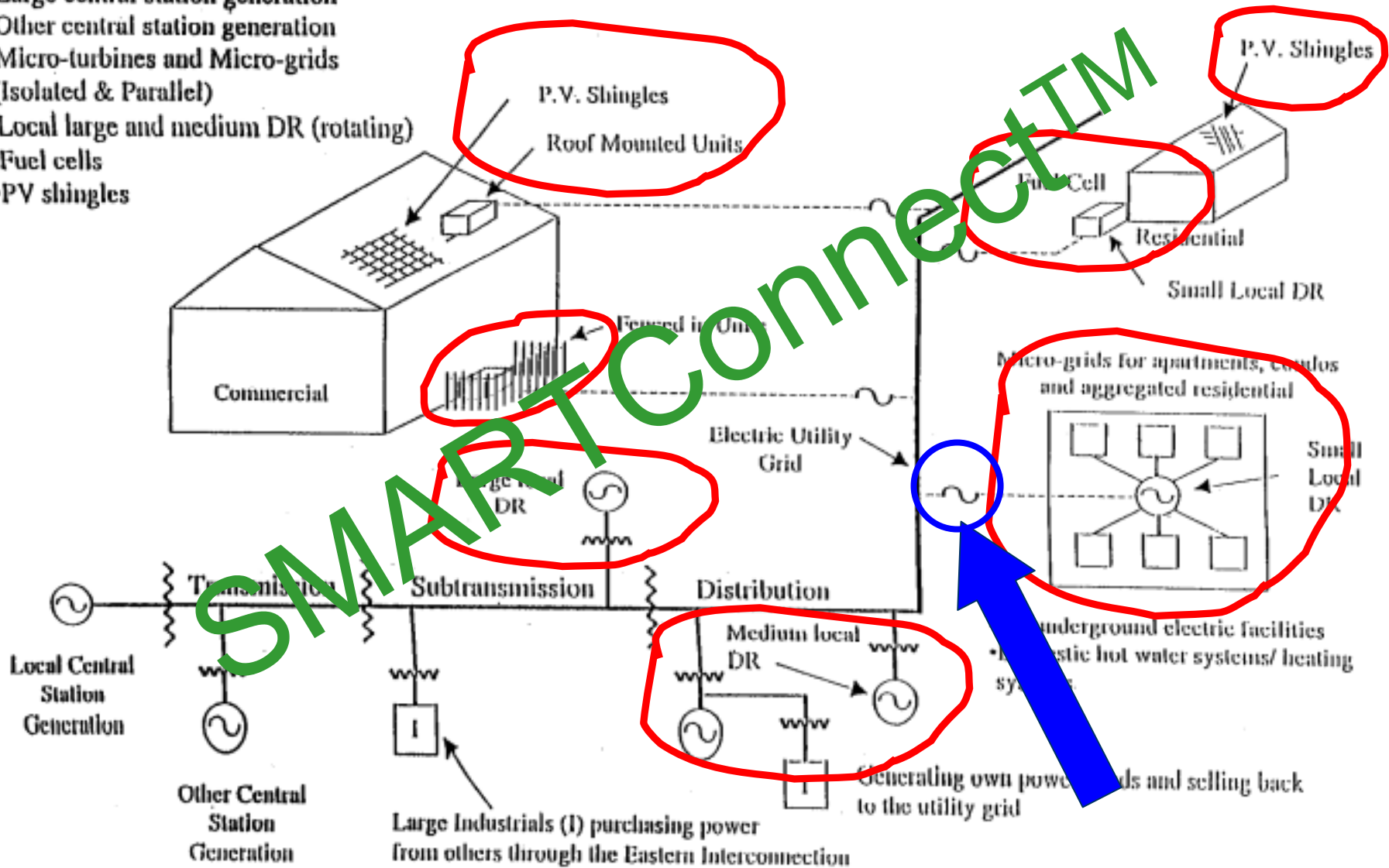
# Electric Distribution System



SMARTConnect™

# What could the power system of the future look like?

- Large central station generation
- Other central station generation
- Micro-turbines and Micro-grids (Isolated & Parallel)
- Local large and medium DR (rotating)
- Fuel cells
- PV shingles



SMARTConnect™ Integration

# Institutional and Regulatory Barriers



- Utility, emission, and local siting and zoning barriers:
  - Varying interconnection requirements
  - Excessive back-up charges, exit fees, procedural delays
  - Selective discounting
  - Insurance and indemnification requirements
- Activities include:
  - UL/ANSI 1741 standard/certification process to cover interconnection equipment for all DER
  - Model emissions rule for small DER
  - Methodology to determine equitable rates for stand-by charges and backup fees
  - Research on innovative tariffs for DER

# Mitigation of Institutional and Regulatory Barriers



- Determine equitable rates for standby charges and backup fees
- Update “Making Connections” report
- Innovative tariffs for DER
- State adoption of DER interconnection rule
- State adoption of DER emissions rule



# Certification and Testing

- Supports all R&D areas
- Certification
  - Interconnection equipment
  - Lab accreditation
  - Quality certification
  - Certification authority
- Testing
  - DER system interconnection test lab
  - DER system integration field test facility
  - Industry collaborative testing

# Objective – Flesh Out D&I Roadmap

	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	→
<b>Technical Standards</b>	IEEE P1547 Published	IEEE P1547.1 Voting Draft IEEE P1547.2 Voting Draft	IEEE P1547.3 Voting Draft		IEEE P1547 Revisions Distribution Systems Standard Review	Body of Standards that Facilitate Mass Produced Interconnection Equipment
<b>Interconnection Technology</b>	Phase I Multiple DER Interactive Field Testing		Phase II Multiple Interactive DER Field Testing	Inverter and Switchgear Based Interconnection Systems		Plug and Play SMARTConnect Interconnection
<b>Electrical Distribution Systems</b>	Distribution System Technology and Needs Assessment	Concepts for Intentional Islanding Interface Certification Process	Advances in Protection Technology Microgrid Demo Approaches for Secondary Networks	Sensors and Control R&D		Advanced Grid Control Advanced SCADA Smart Substations
<b>Barrier Mitigation</b>	Model DER Interconnection Rule Model DER Emissions Rule	Methodology for Equitable Standby and Backup Fees	Innovative Tariffs for DER			Removal of DER Barriers
<b>Certification and Testing</b>	UL/ANSI 1741 Field Test Facility	Interconnection Certification Interconnection Test Lab Industry Testing	Certification Authority Advanced Equipment Testing	Interconnection Certification by Industry Lab Accreditation	Industry Accepts Certification Authority UL 1741 NEC Compliant	Ongoing Certification and Testing

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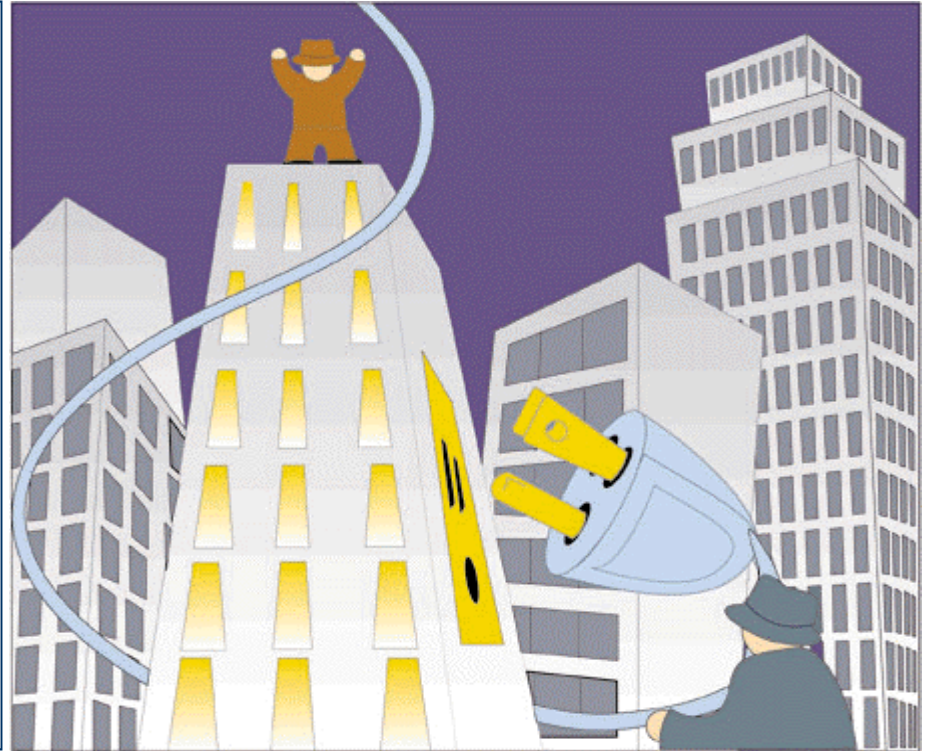
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